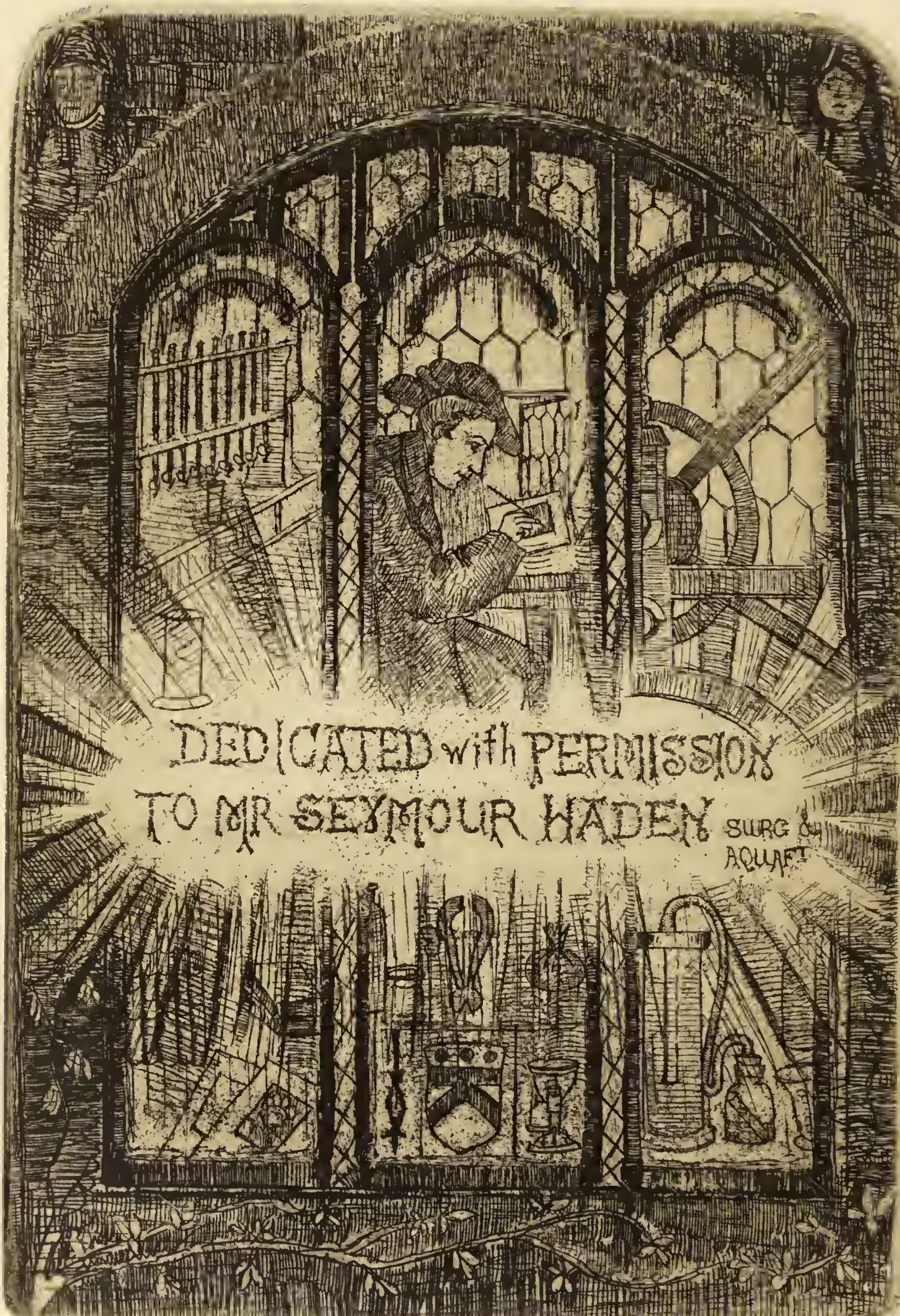
STUDENT'S PRIMER ON THE URINE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STUDENT'S PRIMER

ON

THE URINE

BY

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With Illustrations etched by him upon Copper

LONDON

J. & A. CHURCHILL, NEW BURLINGTON STREET

1880

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PREFACE.

Hospital physicians and clinical students, for whose use this book is more especially intended, will appreciate what to others appears somewhat of a confusion in the chemical and analytical parts, viz., grammes associated with grains, litres and cubic centimetres with ounces, drams, and minims. As the metric system has as yet only won its way into the scientific laboratory, but has not been adopted in our clinical wards, I have given the preparation (supposed, by-the-bye, to be done by the chemist or apothecary attached to the hospital or institution) of the solutions in the metric system, but the results are always given as so many grains to the ounce of urine operated upon. Till the metric system has wholly superseded our irregular English systems, I fear we must be prepared with such expedients, and I shall be most happy to make the necessary

changes if the progress of the better system and the success of the book require it.

The calculations have not been refined by corrections for temperature and barometrical pressure, in order to encourage clinical students to perform analyses daily.

The study of the urine and its chemical investigation is claiming every year greater prominence in professional education. From the facility with which random or ingenious hypothetical answering can be checked, it is also bulking more largely in clinical and qualifying examinations.

The illustrations are, for the most part, the result of observation of some years made during clinical examination of urine for the demonstrations conducted in Dr. Charteris' Wards, Royal Infirmary, Glasgow.

I may be permitted here to call attention to what seems to me the suitability of the etching needle for delineation of microscopic appearances, and the honour I feel in associating the name of a surgeon and aquafortist so celebrated as that of Mr. Seymour Haden, who has done so much to render etching a living art in this country.

J. T. W.

December, 1879.

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STUDENT'S PRIMER ON THE URINE.

URINE is the richest and most varied of the secretions connected with the human economy. The evidences of disease revealed by its physiological observation and chemical investigation are most satisfactory and conclusive. It is a microcosm, so to speak, in which the body represents itself; its operations in health; in disease, its abnormal waste and productions.

In disease the patient will often call attention to the quantity of urine voided being less or more than usual; its altered appearance, whether due to cloudiness, turbidity, high colour, or paleness, abundant or peculiar sediment, odour, or sensation in passing.

SENSATION IN PASSING URINE.

Frequent desire to micturate may arise from abundant secretion, as in diabetes, urinus potus; tenderness of the urinary passages rendering them less tolerant of the fluid, as in catarrh, cystitis,

presence of stone, disease of prostate, urethritis; changes in the urine itself, acidity or acridity of urine; disease or disturbance in sexual and neighbouring organs, metritis, vaginitis, flatulence, loaded bowels, taking drugs or stimulants; nervous excitement, lesion of nervous and cerebral system.

Difficult or painful micturition may be caused by inflammation, obstruction, stricture, spasm of urinary passage (as from exposure to cold) by viscidity of fluid, stone in bladder or urethra, or by drugs.

Quantity.

The normal average quantity of urine voided during the day of twenty-four hours is forty to fifty ounces. In a state of health this average is liable to fluctuation, being increased by repose or want of exercise, exposure to cold, dry skin, and decreased by increased respiration, exercise, warmth, perspiration, and nervous excitement.

Abundant micturition follows abundant secretion, unusual imbibition, taking of fat, use of stimulants, diuretics, alkalies, salines, drugs, cantharides, opium, belladonnæ, on convalescence after fevers, acute diseases, and after nervous attacks.

Decreased micturition may be brought about by use of diaphoretics, increased respiration and

perspiration, drastics, Turkish baths, diseases producing anasarca and dropsy, suppression, uræmia, and fevers.

COLOUR.

Urine is amber-coloured in health; in other conditions the colour may vary from that of nearly clear water to that of porter or ink.

Urine is paler when dilute and abundant, after drinking, in diabetes, excitement of kidney, after hysteria and nervous attacks, in convalescence after fevers and acute diseases; salines and astringents turn urine paler.

Urine is higher coloured when scanty and concentrated, after food, exercise, in bilious attacks and acid indigestion, mental anxieties, in fevers and acute diseases; in rheumatism and gout it is reddish yellow; in inflammation of kidney or acute Bright's disease smoky from admixture of blood; in disease and injury to bladder and urinary passages more or less scarlet from presence of recent blood corpuscles.

In hæmatinuria it is of a port wine colour from hæmoglobin or blood-colouring matter.

Chylous urine is the colour of milk, from the presence of fatty matter in a minute state of division.

In cystitis, pyelitis, urethritis, gonorrhœa,

abscess or suppuration of bladder, prostate, or urinary passages, or disorder of some neighbouring organ or part discharging into urinary passage, the urine is of a muddy greyish-yellow from presence of pus.

In jaundice urine is greenish-brown.

Taken medicinally, iron, logwood turn urine dark; rhubarb, santonin, saffron give it a reddish-colour; carbolic acid absorbed into the body from dressings applied to open sores, or as injections into cavities, turns urine black.

The colour of urine is probably due to indican, a substance nearly identical with indigo, and related to the colouring matter of bile, and again to chlorophyll. It is supposed to be due to the oxidization and disintegration of the red blood corpuscles.

Urine may be deeply coloured by the colouring principle of coffee, when strong infusion is taken even in moderate quantity.

Urine is readily coloured on taking rhubarb, senna, hæmatoxylum, or pyrola. Urine coloured by rhubarb may be mistaken for bilious urine, but this error can be detected by liquor ammoniæ, which turns the dark orange to crimson.

Dark urine of a brownish or brown porter colour, or blackish-grey colour, indicates the rapid disintegration of the red blood corpuscles.

Odour.

Urine possesses a peculiar and special smell. In rheumatism, gout, acid indigestion, catarrh of bladder, the odour is strong; odour of urine is also intensified by acids.

Certain drugs taken internally are detected by their odour in the urine, copaiba, cubebs, sandal-wood oil; asparagus and garlic as food. Turpentine gives odour of violets to urine. Diabetic urine has a sweetish odour, which has been likened to the faint smell of hay or whey.

Urine becoming alkaline, especially so from presence of pus or blood, has a stale disagreeable odour.

Urine containing cholesterine has the odour of sweet-brier, sometimes that of putrid cabbage, from the large percentage of sulphur contained in cholesterine.

Sulphuretted hydrogen may be evolved from urine.

Specific Gravity.

Urine being a saline solution is always heavier than water. Its specific gravity is reckoned by comparison with distilled water, by means of a hydrometer specially constructed for the purpose,

and hence known as a urinometer. The urinometer placed in distilled water floats at the mark 0° or zero, conventionally spoken of as 1000°, and the other numbers in like manner, thus if floating at 21° we say the urine is of the specific gravity of 1021°, or more conventionally still, "ten twenty-one," and so on.

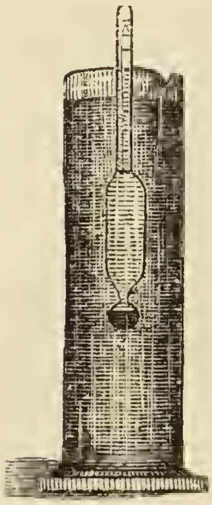


Fig. 1.

The average specific gravity of normal healthy urine is 1015° to 1025°.

The specific gravity is temporarily affected by many circumstances, but only what may be considered permanently by disease.

The specific gravity is high in diabetes mellitus, rheumatism, gout, fevers, and is increased after violent or prolonged exercise, sweating, food. The specific gravity is often low in albuminous urine, in anæmia, in dilute and abundant (except in diabetes mellitus) urine.

If the specific gravity of a urine is above 1030°, we suspect the presence of sugar, and use the tests indicated under "Sugar," p. 24.

Care should be taken that the urinometer float freely without touching the sides of the glass, and more than one sample of the day's urine should be tested.

Reaction.

Normal healthy urine is markedly acid when voided, becomes more so on standing for a period of days, when it gradually turns alkaline, from the presence of ammonia developed from the decomposing acid urea,—thus

$$\text{Urea, } CN_2H_4O = CO_3\ (NH_4)_2, \text{ Carbonate of Ammonia.}$$

The acid reaction of urine is due to acid salts, —acid phosphates of soda and potash, acid urates, oxalic acid, etc.

The reaction is distinguished by litmus paper, blue litmus paper being turned red by acid urine, and red litmus paper blue by alkaline urine.

If the urine changes neither, it is neutral. When on the point of passing from the acid condition to the alkaline, the urine may be found alkaline on the top and acid at the bottom. This is important to remember, otherwise the student will be misled as to the presence of acid crystals (urates, uric acid, oxalates) in what appears to be alkaline urine.

The urine of persons suffering from rheumatism, gout, acid indigestion, uric and lactic acid diathesis will be found markedly acid.

Hot, highly nitrogenous stimulating articles of diet and alcohol increase the acidity of the urine.

Urine is alkaline when voided in severe forms of paraplegia, in cystitis, and when pus is present.

Administration of alkalies and salines in large doses will cause the urine to be alkaline when voided.

Fresh or acid urine quickly becomes alkaline by the addition of a little stale urine or ammonia.*

History and Behaviour, Cloudiness, Turbidity.

Normal and nearly all urines except those containing pus and blood are clear when voided. If dilute when voided it remains clear for a good while, if scanty or concentrated it soon becomes cloudy or turbid.

Soon after voiding, if mucus be present in quantity it forms as a light cloud floating in the urine, which soon sinks, generally forming the first deposit. Mucus disappears as urine becomes alkaline.

Vibrios and bacteria develop, especially in some urines, as the change takes place; afterwards disappearing.

The pellicle often seen floating on the top of urine consists of the phosphates of lime and soda.

* In flannel manufacturing districts it has been the custom to collect and keep the urine till stale (then known as "lant") for cleansing the cloth.

Acid urine may become turbid from presence of urates and acid phosphate of lime, but as urine becomes alkaline these dissolve.

Uric acid crystals are seen in very acid urine, disappearing as urine becomes alkaline.

Blood, pus, and mucus deposit in acid urine, and are partially or wholly dissolved as urine becomes alkaline.

When pus is present urine becomes ropy as it turns alkaline.

Albuminous urine is often opalescent or slightly cloudy.

If froth on surface remains after being voided, suspect albumen or bile.

Blood in urine causes a smoky appearance, or cloudiness varying to turbidity.

In alkaline urine the diffused cloud is composed of triple phosphates of ammonia and magnesia.

Urine is alkaline when voided, or rapidly becomes alkaline in cystitis, paraplegia, or in inflammatory diseases of urinary passages.

Urine becomes turbid when changing into alkaline state, and then may clear.

The amount of acidity in the urine can be estimated by means of a standard solution of caustic soda (Standard solution 12 B, p. 69), graduated so that a certain volume corresponds to a certain amount of oxalic acid.

To 50 c.c. of fresh urine, add the standard solution of soda in small portions, say ½ c.c. at a time, and test after each addition with blue litmus paper. When the litmus paper does not become red any longer the test is complete. If, say 20 c.c. of the soda solution have been used, acidity equal to ·308 grain of oxalic acid is indicated in the 50 c.c., and if two litres (2,000 c.c. = about 3 pints) have been voided, acidity equal to 12·32 grains of oxalic is indicated.

The amount of alkalinity of urine can be tested by applying the standard solution of oxalic acid, until an acid reaction is obtained. Every c.c. of the solution used is equal to ·0154 grain of oxalic acid. If one ounce has been operated upon it is easy to calculate for the number of ounces voided.

Sediment or Deposits.

In fresh urine the commonest deposit is mucus forming a floating mass of cloud or semi-gelatinous mass at foot of glass.

A pink or red brick-dust deposit generally lying on the mucous mass is the deposit of amorphous urates of ammonia, soda, and lime. The urates only exist in acid urine, disappearing as urine becomes alkaline; they are soluble by heat, acetic and other acids, ammonia.

Oxalates of lime, when present, are found on

the hummocky surface of the mucous mass at the foot of the glass, looking like a slight powdering on the top of a wig. Oxalates may sometimes be seen sparkling and adhering to the sides of the glass, if examined against a favourable light.

Uric acid crystals are often large enough to be seen adhering to the sides of the glass, or lying like grains of cayenne pepper amongst the mucus and other sediment. They are the only crystals which show colour under the microscope.

Pus shows as a heavy amorphous greenish-yellow sediment, disappearing as urine becomes alkaline, or on the addition of liquor potassæ.

Blood forms a heavy red amorphous sediment.

In chronic Bright's disease the deposit is very light and flocculent, and symptomatic of tube casts.

Deposits of tube casts, as a rule, come down slowly, and are found on the top of the other deposits.

Phosphates form a heavy whitish precipitate, and are often seen sparkling against the sides of the glass.

Albumen.—$C_{36} H_{56} N_9 O_{11} S$.

Of all the substances in urine, the presence of albumen is the most important indication to the physician. The pathological states in which it

appears are acute and chronic Bright's disease of the kidneys, with or without tube casts; pregnancy and puerperal state; febrile and inflammatory diseases, such as scarlet, typhoid, yellow, and traumatic fevers, measles, small-pox, ague, diphtheria, pneumonia, peritonitis, articular rheumatism, etc.; impediment to the circulation of the blood, such as emphysema, heart disease, abdominal tumours, cirrhosis, etc.; a hydræmic and dissolved state of the blood and atony of the tissues, as in purpura, scurvy, pyæmia, gangrene; in hæmatinuria and in lead poisoning. It of course accompanies presence of blood, pus, and spermatic fluid.

Tests for Albumen.—The tests are heat, nitric acid, carbolic acid, alcohol.

By Heat.—Pour some of the suspected urine into a narrow test-tube, to about the depth of two fingers' breadth—1½ inches. Hold the tube in an inclined position in the flame of a spirit lamp or bunsen burner* (at the same time shaking a little), so that the upper layers of the urine are first heated. Boiling in this way prevents the

* The flame of these being smokeless. In private visiting the want of a smokeless flame is a drawback to the examination of urine; gas and candles being very objectionable in this way. The glowing ashes of a fire; paraffin, petroleum, Argand, and colza lamps (holding the test-tube above the glass chimneys) do not smoke the glass tube.

hot urine from being jerked out upon the hand, and also keeps the albumen from being moved about by the currents set in motion by the heat.

It is quite necessary that the urine be markedly acid when applying this test, as albumen will not precipitate in alkaline urine, but remains dissolved; or if phosphates are abundant they precipitate with the heat, forming a deceptive cloud. A drop of nitric acid will dissolve the phosphates and bring down the albumen, but it is a good rule to acidify the urine with acetic acid before boiling.

Nitric Acid in the Cold.—Fill a narrow test-tube to the depth of an inch with urine, then giving it an inclination of about 45°, allow the nitric acid to trickle slowly down the side of the glass. By its gravity it will go to the bottom of the tube. Where it is in contact with the urine it will coagulate the albumen present. Upon holding the tube perpendicularly, the fluid will be seen in three layers—the clear refractive nitric acid below, the more or less clear urine above, with a cloudy layer of coagulated albumen between. This is a very striking and delicate test for albumen.

Carbolic Acid.—If a drop or two of strong carbolic acid be shaken up with the urine in a test-tube; if albumen be present, the urine will turn quite milky.

Alcohol.—Where albumen is suspected, but is

known to be in small quantities, it is best detected by as much alcohol (rectified or methylated spirits, 60° O.P. as commonly sold) being allowed to trickle with some little force on the top of the urine. A fine layer of the albumen will be seen where the two fluids meet. This test has the advantage of acting as freely in alkaline as in acid urine.

Estimation is made by allowing the precipitate to settle, and then comparing its bulk with the bulk of the urine employed, or by filtering and weighing and calculating the proportion.

An estimation has been proposed consisting of a method of boiling a fixed and acidified quantity of from one to two ounces, filling it, by means of a slit at the top, into a level tube, with opaque metal sides but glass ends, and observing some object, such as the flame of a candle, a square hole against the light in a blackened sheet. If the precipitate of albumen is too dense, it may be diluted with so many times its bulk of water. Calculations could be founded upon experiments.

If the albuminous urine be examined by the polariscope, in the manner recommended for sugar (see page 27), the index will be found to have turned to the left, and the number of degrees read off will give the percentage of albumen.

Chlorides of Sodium and Potassium.

Testing and estimation of the chlorides are unimportant, except in the case of pneumonia. During the acuteness of the attack the chlorides are deficient in the urine, recurring during resolution.

About 250 grains are secreted in the twenty-four hours by a healthy man.

Estimation:—The chlorides are precipitated in acid urine by excess of nitrate of silver; the precipitate filtered and weighed.

Or if a standard solution of nitrate of silver were allowed to fall drop by drop into a measured quantity of the urine, to which two or three drops of a solution of neutral chromate of potash had been added, till a reddish tinge is produced by the drop, we can calculate from the amount of silver used the amount of chlorine combined, and hence the chlorides present.

Estimation of the chlorides by nitrate of silver, in a standard solution (Standard solution 8, p. 67), proceeds thus:—

A fixed quantity of the urine, say 1 oz., is first to be qualified by the addition of two or three drops of yellow chromate of potash in saturated solution. The standard solution of silver is then allowed to drop in the urine till a reddish tinge (from the chromate of silver) begins to show,

disappearing on stirring. With the first drop producing the reddish tinge that does not disappear by stirring the process is finished, and the quantity of the standard solution used read off.

By the formulæ $NaCl + AgNO_3 = AgCl + NaNO_3$ 58·5 parts by weight of NaCl are indicated by 143·5 parts of the precipitate, and 170 parts of silver nitrate will precipitate this amount of NaCl or 1·7 parts $AgNO_3$ indicate ·585 parts of chlorides in the urine. Then if a solution of nitrate of silver be made containing 1·7 grains to the c.c., this would form a standard solution, indicating for every c.c. of it used to form the precipitate a weight of ·585, or roundly ·6 grain of chlorides.

Solution of nitrate of mercury (Standard solution 6 B) will also serve for estimating the chlorides. After clearing the urine of the phosphates with the baryta solution, the nitrate of mercury is allowed to drop in gradually. The chloride of mercury formed is soluble in the urine, and the process is continued till signs of a permanent precipitate (nitrate of urea) begin to appear.

Supposing 1 oz. of the urine to have been experimented upon and 15 c.c. of the Standard solution 6 B, have been used before the permanent precipitate appeared, then the urine contains 15 grains of chloride of sodium to the ounce.

Ammonia.—NH_3.

The presence of free ammoniais detected by the odour; by suspending moist red litmus paper over the urine while being gently warmed, or by bringing the fumes of hydrochloric acid near to gently warmed urine.

The free ammonia in urine may be estimated by placing a measured quantity of the urine, to which milk of lime is added, under an air-tight bell-glass, under which is also placed a shallow vessel containing a measured quantity of titrated* acid. In the course of twenty-four hours or so, all the ammonia will have passed out of the urine into the acid, which is then titrated with standard alkali to find the amount of ammonia absorbed.

Urea.—CN_2H_4O.

As representing nitrogenous waste, urea is an important element to estimate in acute and wasting diseases, in diabetes, fevers, rheumatism.

In health it is secreted at the rate of 300 to 500 grains daily. The amount is subject to much variation according to the state of the body, exercise, digestion, food; being increased by a high meat diet and decreased by a mild or

* Titrated = tested with a standard solution, calculated on the basis of molecular weights. See also p. 9.

vegetable one. In chronic Bright's and allied diseases the amount is below the average.

Urea is very soluble in urine, but in excess forms a copious sediment in combination with the ammonia, soda, potash, and lime. This precipitate is readily dissolved by heat, nitric acid, ammonia.

Estimation of Urea.—Urea may be estimated by three methods—Liebig's, the hypo-bromite, and the nitric acid.

1. *Nitirc Acid.*—When colourless nitric acid in excess is added to urine concentrated to a fourth or sixth of its volume and cold, nitrate of urea crystallizes out in large, brilliant, yellow laminæ, which are very insoluble in the acid liquid. The formula for nitrate of urea is $COH_4N_2NO_3H$, and the weight of the crystal is to the urea as 123 : 60.

2. The *hypo-bromite* method is the readiest and most convenient. It is a volumetric method, depending upon the measurement of the nitrogen liberated from the urea. The amount of urea is then calculated from the formula.*

The accompanying drawing represents the apparatus for this purpose, arranged so that the amount of urea is indicated at once. The tall jar is nearly filled with water, and the cork fits loosely, acting merely as a support to the inverted burette.

A flexible tube connects the burette with the generator, consisting of a small test-tube inside a wide-mouthed phial, closed with an india-rubber cork.

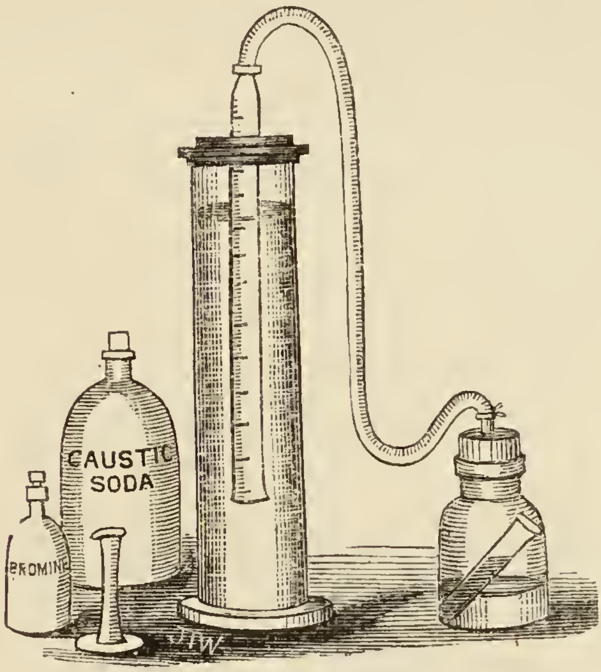


FIG. 2.

The solution of hypo-bromite is prepared by adding 40 minims of bromine by measure to 420 minims of solution of caustic soda in water (one of soda in two and a-half water). This is put into the wide-mouthed phial. Then 65 minims of urine by measure are put into the test-tube, which is carefully slid into the phial without spilling. The phial is now securely corked, and we note the level of the water in the burette. By cautiously inclining and shaking the generator, we allow the urine and hypo-bromite to mix. Effervescence takes place, the nitrogen passes

over to the burette and depresses the surface of the water. The number of degrees it is lowered gives the measured units of nitrogen, representing the urea in grains, or grains of urea per ounce of urine, as the markings on the burette may be arranged for. (See p. 71.)

Liebig's method is less handy. Three solutions are necessary:—

First, a standard solution of nitrate of mercury (Standard solution 5 A).

Second, a solution of baryta (Standard solution 7).

Third, a saturated solution of carbonate of soda.

One volume of the baryta solution is added to two of the urine, and the mixture filtered. If the mixture shows a precipitate with more baryta solution added, begin *de novo* and add one volume of the baryta solution to one of urine. The precipitation by the baryta solution removes the phosphates from the urine. Next take as much of the filtrate as contains 10 c.c. (·6 cubic inch) of the urine, and acidulate with a few drops of nitric acid. The nitrate of mercury solution dropped from a graduated burette is stirred into the filtrate till a permanent precipitate begins to appear, when the amount of nitrate solution is noted. The nitrate is again added drop by drop, till a drop of the solution gives a yellow colour with the soda solu-

tion. The amount of nitrate solution used between the production of the precipitate and the yellow discoloration with soda, multiplied by ten, gives the amount of urea.

Multiply the amount of urine used in the experiment by the amount of urine passed in the day to obtain the daily secretion of urea.

Phosphates.

The exhausted phosphorus of the body appears in the urine as acid phosphate of lime, phosphate of soda, and as the triple phosphates of ammonia and magnesia.

The estimation of the phosphorus in the urine is of the utmost importance to determine the waste going on in disease, just as the determination of the urea shows whether the secretory apparatus is satisfactory.

Estimation of the Phosphorus. — Acidify urine (50 c.c.) with (5 c.c.) of a standard solution of acetate of soda (Standard solution 10). The acidulated urine is warmed on a water bath, and a standard solution of acetate of uranium (Standard solution 9) is added drop by drop till precipitation ceases. If a drop of the liquor brought into contact with a drop of ferrocyanide

of potassium turns brown, the operation is finished; but if it turns blue more of the uranium solution must be added. The number of c.c. of the uranium solution used multiplied by 5 will give in milligrammes the amount of phosphoric acid in the specimen. The milligramme = ·0154 English grain.

The earthy phosphates are estimated by adding caustic liq. ammonia and sulphate of magnesia in excess and stirring briskly. Wait till precipitate falls and urine clears. Filter and ignite when 100 parts of residue contain 63·96 parts of phosphoric anhydride (P_2O_5), and phosphorus equals 62 out of 142 parts. So that

$$\frac{\text{weight of residue} \times 63{\cdot}96 \times 62}{100 \times 142} = \text{phosphorus.}$$

Blood.

If actual blood discs are contained in the urine examination under the microscope is the readiest and best test. Blood discs voided with the urine are liable to be changed from steeping in the urine. Rouleaux are seldom seen. The discs get warped, and in time the colour and body are washed out, leaving the empty shell looking like a ghost of its former self. Hence I name these skeleton corpuscles. In these cases and in hæmatinuria, we fall back upon the blood-

colouring matter, hæmoglobin, and test for it by three tests—the guaiacum test, Heller's test, and the spectroscope.

The Guaiacum Test.—Add a few drops of tincture of guaiacum to a small quantity of urine in a test tube; then about as much ozonised ether (solution of peroxide of hydrogen in ether) as there was urine. If blood-colouring matter be present, a sapphire blue colour will be produced.

Heller's Test.—The urine is rendered alkaline with liquor potassæ or sodæ, heated to boiling point, and set aside. The precipitated phosphates are of a greenish or reddish colour if blood colouring matter (hæmoglobin) be present.

By the Spectroscope—The spectrum of urine containing hæmoglobin, will show certain well-marked

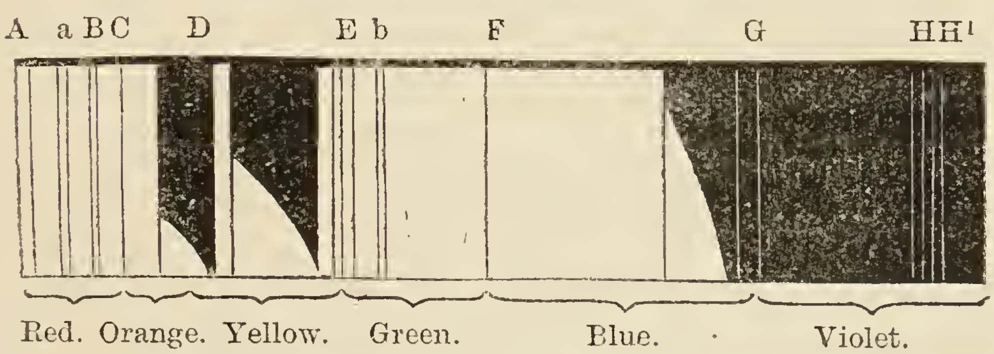


Fig. 3.

absorption bands. If recently voided and consequently highly acid, three bands—C, D, E,—will appear.

If somewhat old the absorption bands at D and E only will appear.

SUGAR.

In diabetes mellitus the amount of urine secreted daily may amount to more than 300 ounces, and the sugar to 25 ounces. Although the patient has a ravenous appetite, emaciation results, accompanied by languor, and other evils. The detection and estimation of sugar, therefore, is of the utmost importance. The following are the usual tests:—

Moore's Test.—Equal parts of urine and liquor potassæ (B.P.) are boiled together in a test-tube; when coming near the boiling point, if sugar is present, the fluid begins to show a pale lemon or canary colour, which immediately goes on to deepen in tone to a pale sherry colour, then to a fine claret. The changes take place in the hottest part of the tube first, the rest following so that graduated tints are noticed during the boiling.

Trommer's Test.—Equal parts of urine, liquor potassæ, and (10 grains to ounce) solution of sulphate of copper are mixed together in a test-tube, and shaken till they clear. Upon boiling, and when near the boiling point, the clear mixture suddenly becomes opaque with a fine orange-red precipitate of the sub-oxide of copper, which rapidly darkens to brown.

Lowe's Test, or Bismuth Test.—Dissolve 15

grammes of subnitrate of bismuth in glycerine 30 grammes, and solution of sodium hydrate (specific gravity 1·34) 60 to 70 c.c., and dilute with 150 to 160 c.c. of water. Heat to 100° Cent. (212° Fahr.), let stand and decant; test performed by adding a little to the urine and boiling. Black precipitate falls if sugar is present. No positive conclusion to be formed if precipitate is grey or light coloured. Before testing urine albumen may be removed, and urine filtered of mucus, urates, etc.

Fehling's Test (Standard solution 4).

As a qualitative test, Fehling's solution is readiest and best. Put about a dram of the solution in a test-tube and boil, add a drop or two of the diabetic urine, when, after an instant's pause, the mixture will suddenly become opaque with a solid-looking orange red precipitate, which rapidly darkens to red, then brown.

Quantative Test.—Allow 10 c.c. of the standard Fehling's solution to run from the burette into a capacious porcelain dish and dilute with 50 c.c. of water. Put 1 c.c. of urine in another burette, and add 10 or 20 c.c. of water according to quantity of sugar suspected. Boil the copper solution, and allow the diluted urine to run into it. When the blue colour is fast disappearing the diabetic urine needs to be cautiously added,

and when the mixture is quite colourless the process is complete. The urine may be added as long as the drops produce a yellow cloud on the surface of the copper solution; when this ceases the urine may be set aside to cool.

As 10 c.c. of the copper solution indicate the presence of 1 grain of sugar in the diabetic urine; therefore, whatever quantity of the urine has been used, it contained 1 grain of sugar. Thus, if 10 c.c. of the diluted urine (supposing it to have been diluted twenty times), that would be equal to ·5 c.c. of undiluted urine, and that again to 1 grain of sugar. If, say, 5 litres (equal to about 9 English pints) are passed *inter diem*, the sugar would be equal to 1000 grains, 5 litres being equal to 500 c.c., or 1000 half c.c.

Fermentation Test.—Estimation by density. The diabetic urine is fermented by adding a few grains of German yeast, and keeping for twenty-four hours in a moderately warm place. The difference in degrees by the urinometer of the densities before and after fermentation, represents the number of grains of sugar per ounce of urine.

Polariscopic Test.—Polariscopes for the purpose of testing for sugar are fitted with a metallic tube, having glass ends, and a slit along the top by which to fill it. This tube fits into the inside of the instrument. The instrument is first set by

observing distilled water, the field being divided into two equal parts by a black line, and the screw and button adjusted till the two halves are of the same colour and density. The distilled water is then replaced by the urine, and the screw turned till both halves are again of the same tint. If sugar is present the scale will have gone to the right; if albumen, to the left. The number of degrees will give the percentage.

Comparison Test.—If a solution of grape sugar, half a grain to the ounce, be boiled with the standard solution of liquor potassæ, it may be placed in a burette or tube for comparison as a quantitative test. Thirty minims by measure of a suspected urine are put in a flask or large test tube, and an equal quantity of the liquor potassæ added. The measure may be washed out with a dram or two of water, and this added to the mixture in the flask. The mixture is now boiled, and then poured into a burette beside the standard for comparison. The mixture is now diluted with water, till of the same tint as the standard. The amount of sugar in the urine is calculated by multiplying the half grain by the amount of dilution. Thus, suppose the urine has been diluted to twenty-five times its original bulk, it will contain twenty-five half grains of sugar to the ounce.

Bile.

Bile in urine gives it more or less a greenish tint, and causes it to remain frothy after voiding.

Gmelin's Test.—A few drops of the urine and nitric acid are placed separately on a plate, dish, or saucer, and allowed to run together. At the line of contact will be seen a play of colours from green, violet, and blue, to red, the most characteristic being green. Or if the nitric acid be poured into a test tube to the depth of half an inch, and the same quantity of urine allowed to trickle down the sides of the tube, the play of colours representing the oxidization of the colouring matters will be seen.

Pettenkofer's Test.—A small quantity of the urine containing bile is poured into a test tube or dropped on a white porcelain surface, and a drop of saturated cane sugar added: strong sulphuric acid (the same quantity as of urine) is dropped in the mixture, and a moderate heat applied. A beautiful cherry red replaced by deep purple is the result. This test is often untrustworthy.

A better way is to put a couple of drams into a test tube with a small fragment of loaf sugar. Then about half a dram of strong sulphuric acid is slowly added in such a manner that the two

fluids do not mix. After standing a few minutes a deep purple hue will be seen at the line of contact.

Hoppe's Method.—The alkaline salts of bile can be separated by rendering the urine faintly alkaline with caustic ammonia, then diacetate of lead added as long as precipitation occurs. The precipitate is washed on a filter boiled with alcohol over a water bath and filtered hot. A few drops of soda or potash are added to the filtrate, and the solution evaporated over a water bath. The residue is again boiled with absolute alcohol over a water bath, and then dissolved in an excess of ether, when the salts will crystallize out, and can be tested for bile by any of the foregoing tests.

MICROSCOPICAL APPEARANCES

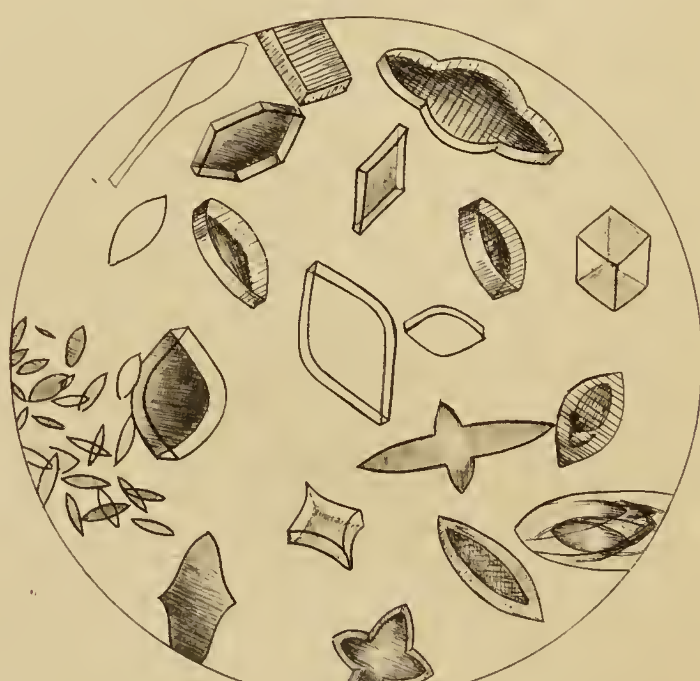
OF

THE SEDIMENT AND DEPOSITS.

To obtain the crystals, etc., the urine must not be fresh, but have stood some time in order to allow the sediment to fall.

Specimens of the deposit to be examined are to be taken out with the small pipettes described on page 63. A drop is allowed to run on the slide, the disc then dropped on, not flatly, but by inclining it, so that one edge touches the slide first. The superfluous fluid is taken up with a small slip of blotting paper. A quarter-inch objective will be found the most useful.

I



JTW 79

PLATE I.

Amorphous Urates of Soda, Ammonia, Lime, etc.

× 200.

Seen as a copious pinkish or light brick-dust deposit in acid urine. Soluble by heat, dilution, acids, and alkalies. More abundant in rheumatism, fevers, acute diseases, after food, exercise, perspiration, and after attacks of gout, hysteria. Less abundant or absent in dilute urine, diabetes, after imbibition, repose; during gout, hysteria. Consist of uric acid, 94·36; ammonium, 1·36; sodium, 1·11; potassium, 3·15. The amorphous form taken by the salt is caused by the chloride of sodium in urine.

Uric Acid or Lithic Acid Crystals.— × 100. $C_{10}\,H_4\,N_4\,O_6$.

Typical form that of a blunt lozenge. Strong raw sienna colour. The only crystals that show colour under the microscope. Found only in acid urine. May be seen adhering to sides of glass, or lying, like cayenne-pepper grains, among mucus or other sediment. Soluble in alkalies and acids. Quantity of deposit depends very much upon action of the skin and lungs, being greater when they are sluggish and *vice versâ*.


J.T.W. '79.

PLATE II.

Uric Acid Crystals—Rarer Forms.

× 100.

a. Glomeruli, like cayenne-pepper grains, easily seen by the naked eye. Probably origin of gravel, calculi. In these forms the acid is in larger quantity.

Uric acid can be procured from urine by adding 5 per cent. of pure hydrochloric acid and allowing to stand some hours in a warm place. The crystals can be separated by filtering and washing.

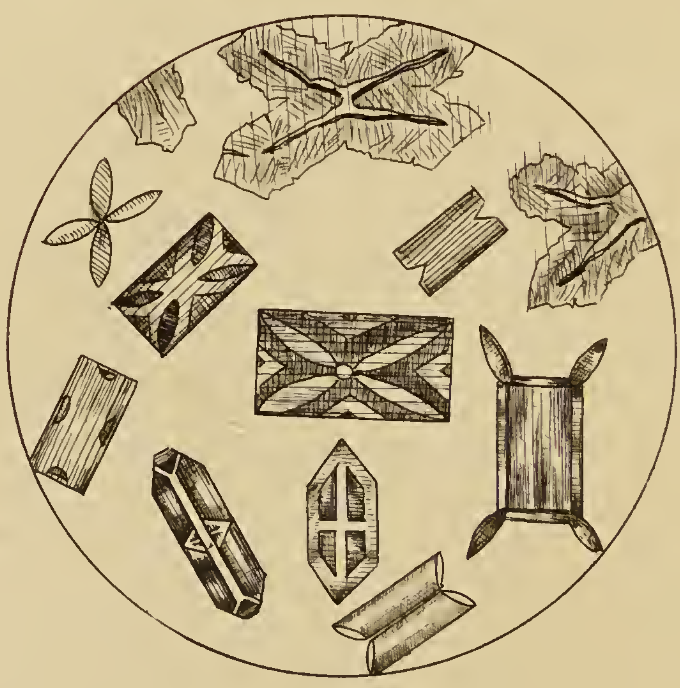
Uric Acid Crystals—Rarer Forms.

× 100.

Acid strong. Mostly result of acid fermentation of amorphous urates.

Uric acid dissolved in dilute nitric acid forms alloxantine, $C_8\,H_4\,N_4\,O_7 + 3\,H_2\,O$. If ammonia be added a beautiful purple product is formed, = murexide, or purpurate of ammonium, $C_8\,H_4\,N_4\,O_7 + 2\,N\,H_3$.

III



J.T.W.79

PLATE III.

The Triple Phosphates of Ammonia and Magnesia, or Earthy Phosphates.

$NH_4O, 2\ MgO, P_2\ O_5 + 12\ HO.$

× 40.

Found in alkaline and ammoniacal urine. May be seen glittering on sides of glass. Mostly of the truncated prism order. Soluble in caustic ammonia, but almost immediately re-form as the feathery phosphates. Excess of these phosphates secreted in mollites ossium and acid dyspepsia, albuminuria.

Other Forms of the Triple Phosphates.

"Envelope" Forms.

× 40.

a. The markings on some of these crystals are caused by partial re-solution.

IIII

J.T.W./82

Jno—del. et sculpt

PLATE IV.

Stellar Phosphates of Lime.—3 CaO, P_2 O_5.

× 150.

Found in acid urine. Often as a pellicle floating on the surface; in combination with a peculiar fatty matter,—kiestin, said to be characteristic of pregnancy. Crystals soluble in strong acids, albumen, and mucus. May be thrown down by chloride of calcium and glycerine.

Feathery Phosphates—Form of Triple Phosphates.

× 350.

Sometimes deposited spontaneously. If liq. ammonia and sulphate of magnesia are added to most urines in excess, the feathery phosphates begin almost immediately to form, and can be easily observed under the microscope.

V

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PLATE V.

Oxalates of Lime.—$C_2 Ca_{11} O_4$, 4 HO.

× 220.

Octahedral in shape, like two pyramids set base to base, having one axis shorter than the two others. Very refractive, more so than the phosphates. May be seen glittering on the sides of the glass, if held against a favourable light, especially sunlight. Oxalates settle slowly, and are often found dusted over the hummocky surface of the deposit of mucus, forming the "powdered wig" deposit. Small fragmentary crystals are common, and apt to be overlooked. Mounted in Canada balsam they polarise with a good light.

Dumb-Bell Crystals of the Oxalates of Lime.

× 220.

Comparatively rare. The oxalate of lime in association with organic matter, which prevents it from assuming its usual characteristic crystalline shape.

VI

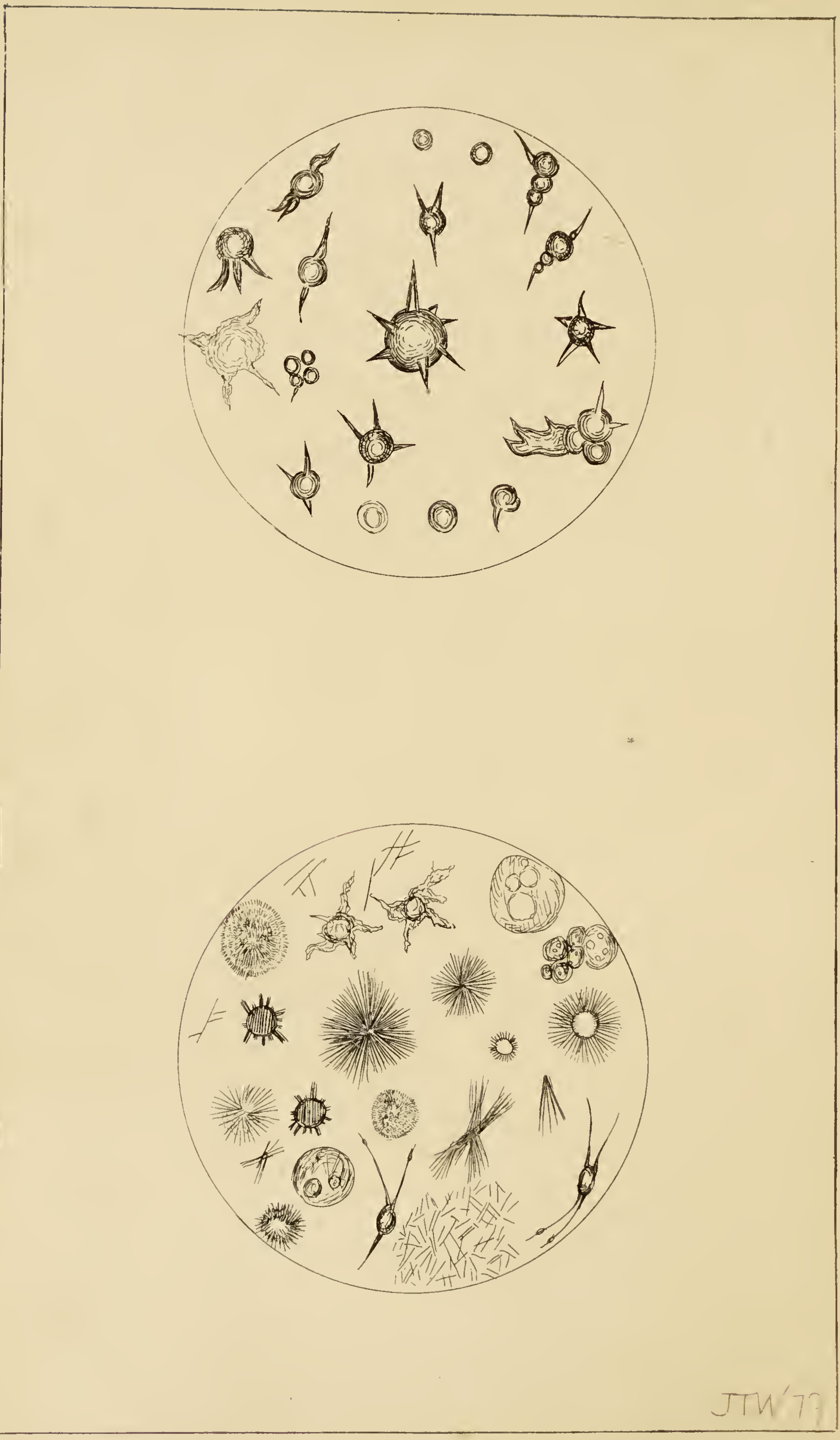


PLATE VI.

Urates of Soda.

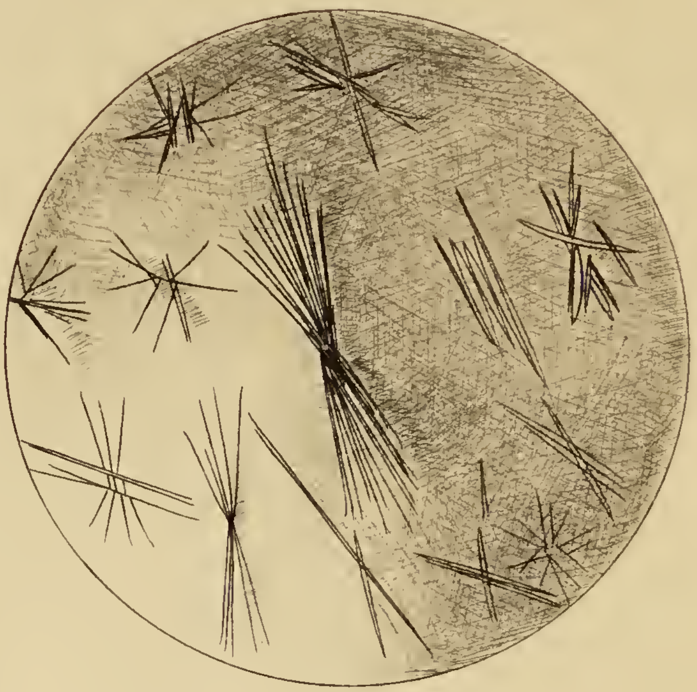
× 220.

They form the pasty deposits or chalk stones in gout.

Urate of Ammonia.

× 220.

VII



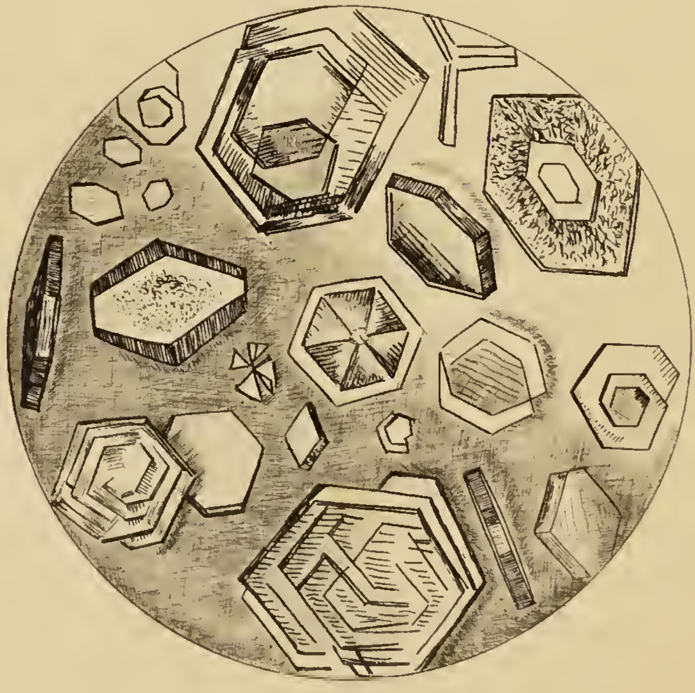


PLATE VII.

Cystine.—$C_4 H_7 NS_2 O_6$.

× 200.

Six-sided crystals, containing 26 per cent. of sulphur. Insoluble in boiling water, strong acetic acid, and weak hydrochloric acid. Soluble in mineral acids and ammonia. If present in urine may be thrown down by acetic acid. Urine containing cystine has the odour of sweet-brier, but sometimes that of putrid cabbage, owing to the sulphur. I once met with cystine (as well as cholesterine and tyrosine) in the fluid tapped from a case of empyema.

Tyrosine.—$C_9 H_{11} NO_3$.

× 150.

Said to be found in urine in cases of acute yellow atrophy of liver, small-pox, typhoid fever, and acute tuberculosis. It may be prepared by boiling horn, feathers, hair, with sulphuric acid for forty hours. Upon neutralizing the fluid and evaporating, the crystals are deposited. Hoffman tests for tyrosine by adding a solution of nitrate of protoxide of mercury, nearly neutral; a reddish precipitate is produced, and fluid is of a dark-rose colour.

VIII.

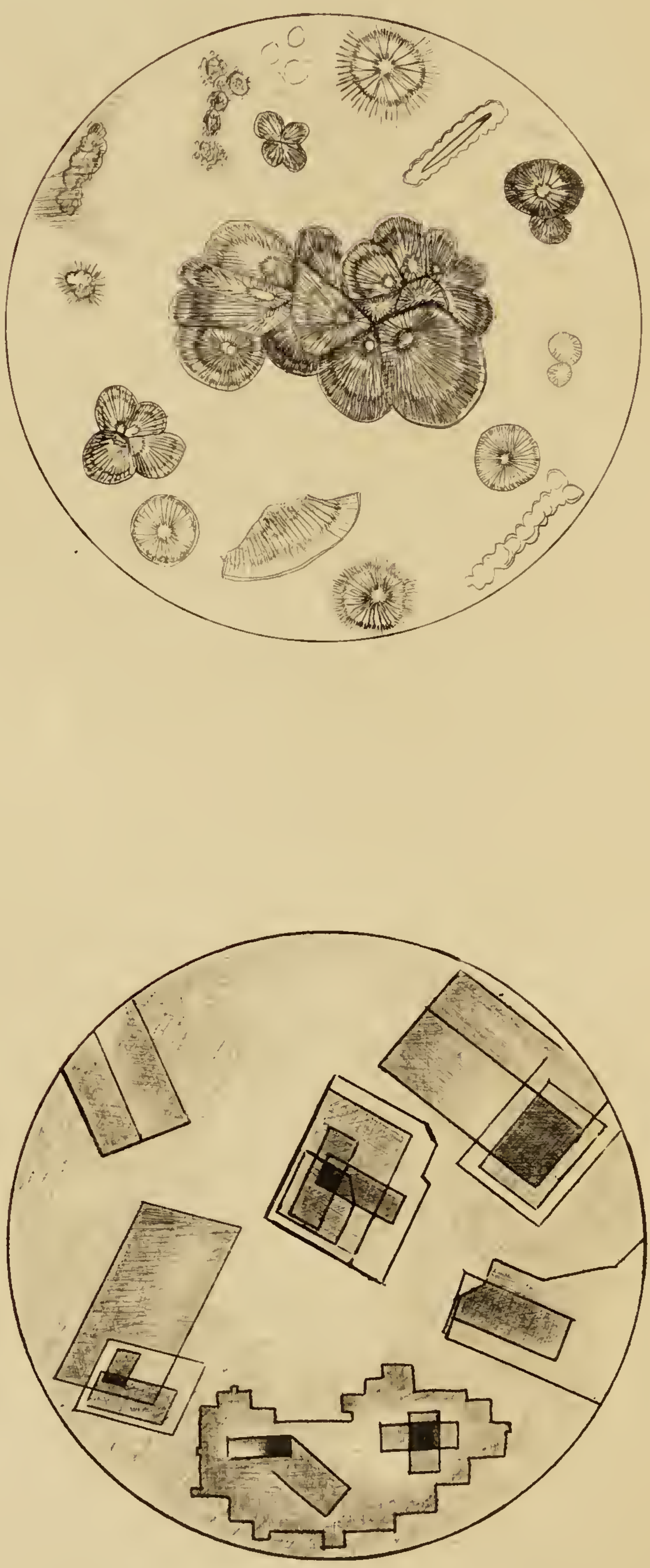


PLATE VIII.

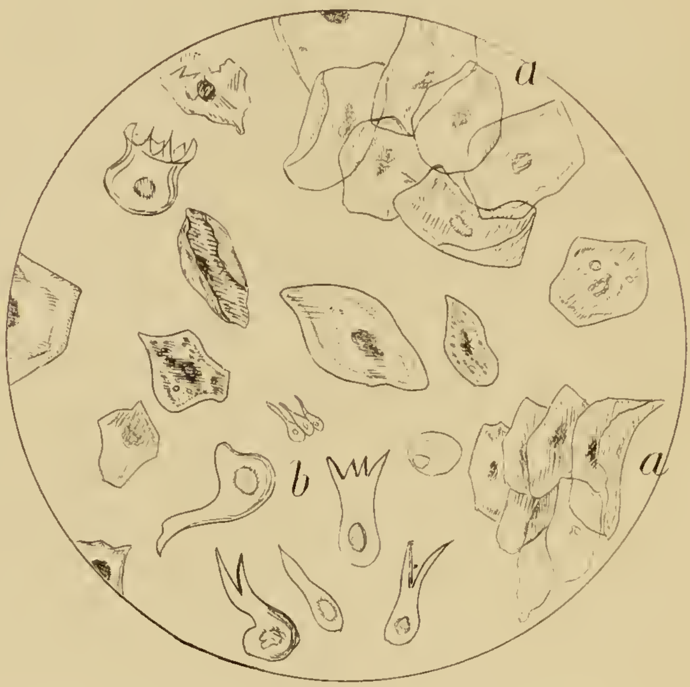
LEUCINE.—$C_6 H_{13} NO_2$.
$\times$ 200.

When present in urine generally in solution and requires concentration. Leucine has been found in many of the solids and fluids of the body. Found in sections of the liver in jaundice. Can be obtained in conjunction with tyrosine from horn, feathers, etc.

CHOLESTERINE.—$C_{26} H_{44} O = C_{26} H_{43} (HO)$.
$\times$ 150.

Said to be found in urine of patients with fatty degeneration of kidney. Found in the Smegma preputii—the secretion of the sebaceous glands behind the glans penis, and associated with oil globules in urine. Cholesterine forms the chief ingredient of biliary calculi. The crystals are insoluble in water, but soluble in spirit, ether, and fats.

IX



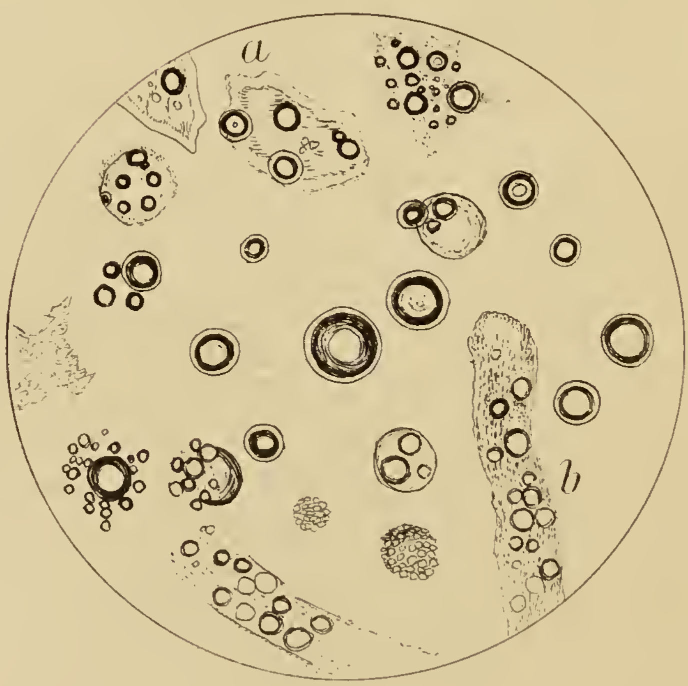


PLATE IX.

Epithelium.

× 150.

a. Squamous, or pavement epithelium, from vagina.

b. Epithelium from ureter, urethra, bladder.

Fat Globules.

× 250.

a. Fat globules formed in association with degenerated epithelium.

b. Entangled in streaks of mucus.

X

PLATE X.

Blood Casts.

× 200.

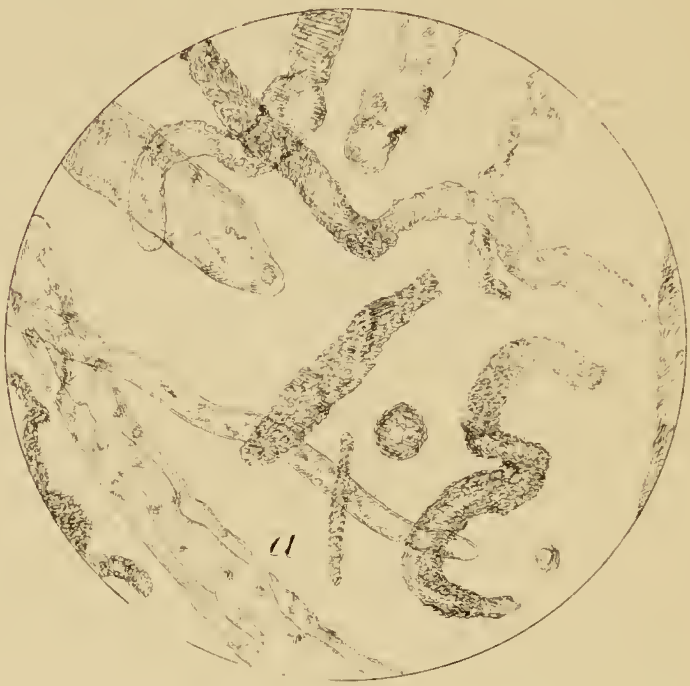
From cases of acute nephritis. Casts about 1-700th of an inch in diameter. The globules have their origin in or near the Malpighian body.

Epithelial Casts.

× 200.

From cases of acute nephritis. Casts about 1-700th of an inch in diameter.

XI



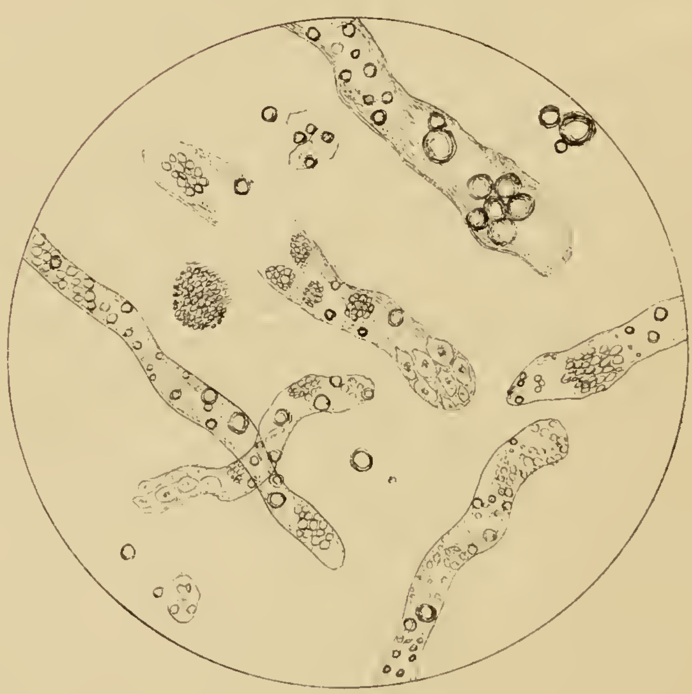


PLATE XI.

Granular Casts.

× 200.

From cases of acute and chronic Bright's disease; more abundant in the chronic stage.

a. One cast enclosing another.

Fatty Casts.

× 200.

From cases of fatty degeneration of the kidney, acute nephritis, chronic Bright's disease. In adults recovering from acute nephritis it is quite common to find oil globules on the casts.

XII

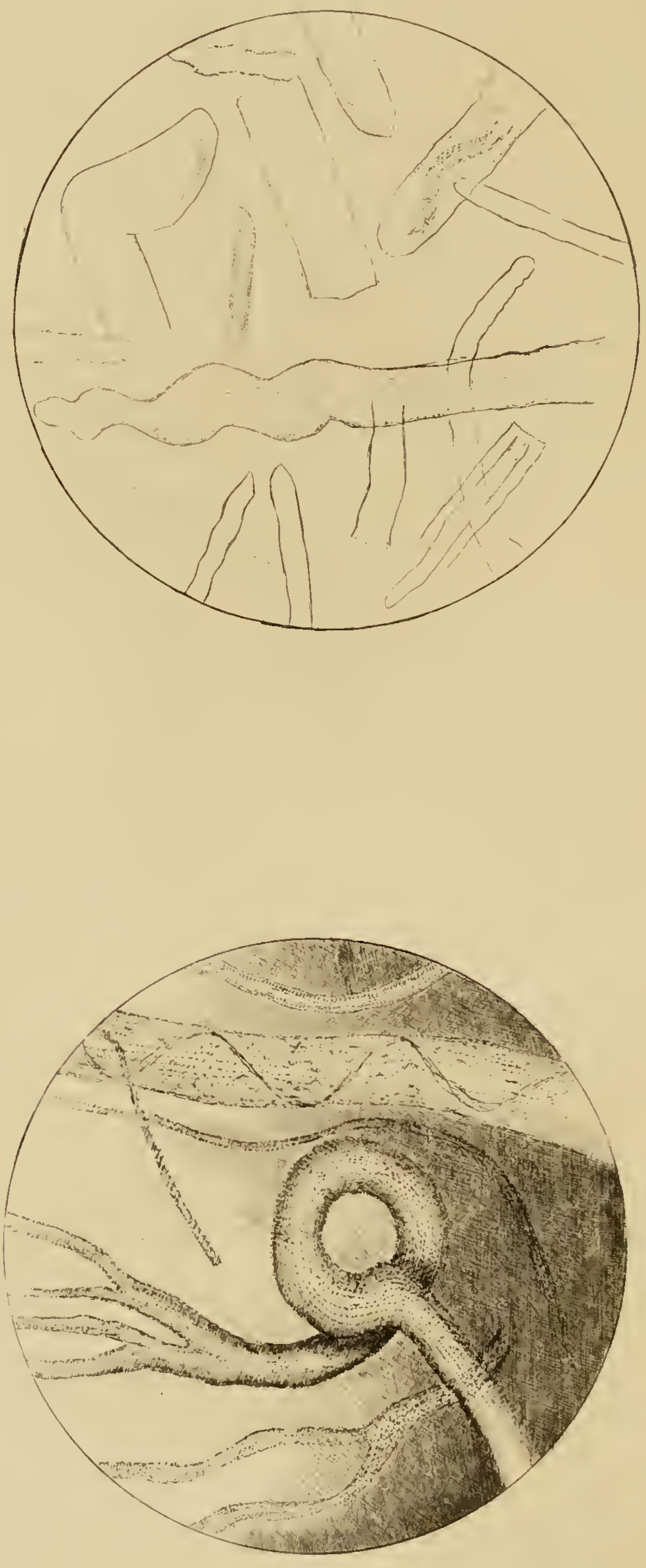


PLATE XII.

Waxy or Hyaline Casts.

× 200.

From cases of waxy degeneration of the kidney; acute and chronic Bright's disease. The small casts about 1-1000th of an inch in diameter. The small casts are derived from tubes in which the epithelial lining is entire, hence symptomatic of non-desquamative nephritis. Some again may come from tubes contracted by disease.

Mucous Casts.

× 100.

These casts may be observed without albumen being detected in the urine. Mucous casts of the seminal tubes may be sometimes found, but are generally associated with spermatozoa.

XIII

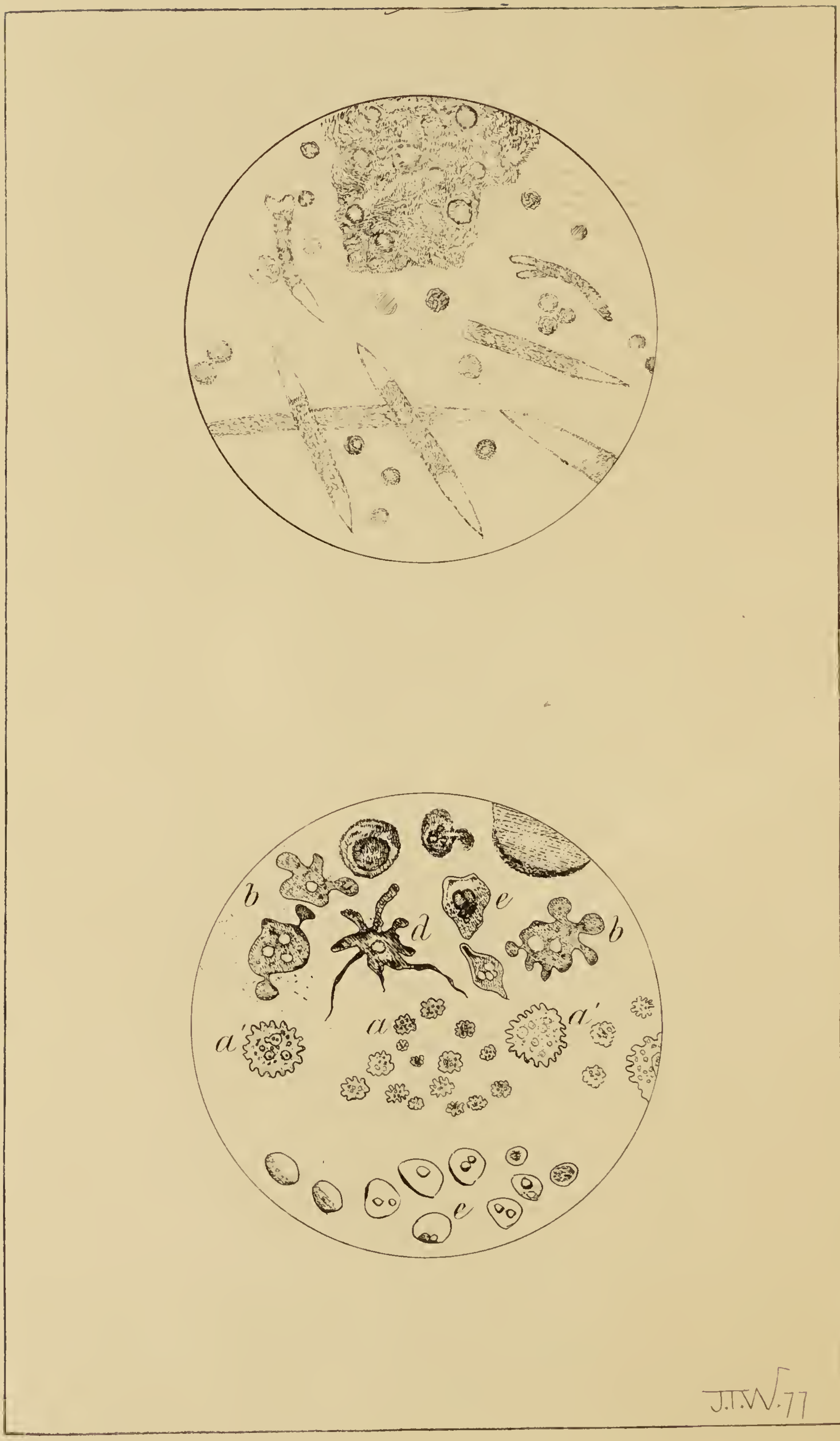


PLATE XIII.

Mucus, Mucous Globules, and Mucous Streaks.

× 150.

Given off when mucous surfaces are excited to extra secretion. The mucous streaks require a very favourable light for their observation. Imperfectly formed cells, generally from the follicles of the urethra and prostate frequently distributed through the mucous masses.

Pus.

× 150.

a. Ordinary appearance of pus in urine.

a′ a′. Enlarged, to show crenulation, granules, and nuclei.

b. Corpuscles multiplying by fissiparous division.

c. Epithelial scales breaking down into pus.

d. Pus cell showing amœboid movements.

e. Pus cells after the addition of acetic acid.

Pus may be found in urine without much derangement of mucous surfaces, just as in discharges from nostrils and throat.

Addition of liq. sodæ or potassæ to purulent urine clears it, and it then becomes ropy.

XIV

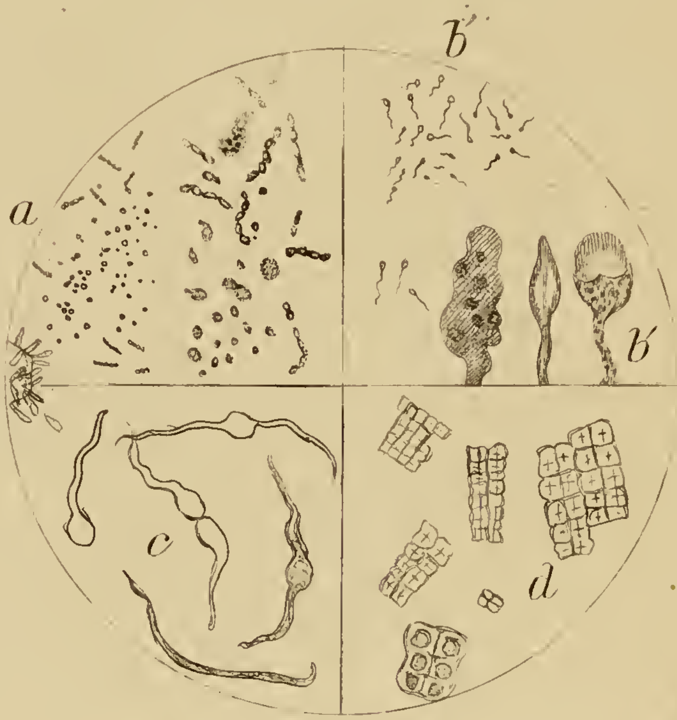


PLATE XIV.

a. Bacteria (globules) and vibrios (rods).

a'. Same under a higher power.

b. Spermatozoa.

b'. Same very much enlarged, showing the heads or cells.

c. Fungus occasionally met with in urine.

d. Sarcinæ, from vomit.

Blood.

a. Blood corpuscles, seen under various powers.

b, b. In rouleaux.

c. After being some time in urine—corpuscles twisted.

d. Ordinary appearance of corpuscles after being some time in urine—the corpuscles losing their biconcavity and becoming spherules.

e. "Skeleton" corpuscles—the colouring matter and substance washed out of the corpuscles, from being immersed in the urine.

f. Blood corpuscles breaking up, and after acetic acid

XV

J.T.W. 77

PLATE XV.

Mould Fungus—Penicilium Glaucum.

Seen in some acid urines containing albumen after considerable exposure to the air. May be met with in saccharine urines.

Yeast Fungus—Torulæ Cerevisiæ.

Showing fructification. Sometimes developed in considerable numbers within twenty-four hours after diabetic urine has been passed.

XVI

PLATE XVI.

Extraneous Matters.

× about 150.

a. Fragment of human hair.

b. Fragment of cats' hair.

c. Muscular fibre.

d. Oil globules.

e. Starch grains.

f. Feather ; *o*, knotted portion from lower part of shaft.

g. Fibre of silk.

h. Portion of tea leaf.

i. k. Flax fibres.

j. Air bubbles.

l. Cotton fibres.

m. Bread crumb.

n. Hairs from blanket.

p. Portion of potato.

q. Portion of wheat.

r. Wood fibres.

The figure (Fig. 4) represents a urinary test stand arranged for convenient analytical work in hospital. The frame is arranged to hold about one dozen burettes, to contain the standard solutions; the bottles from which they are replenished standing at the back, one or two of which are shown (*f*).

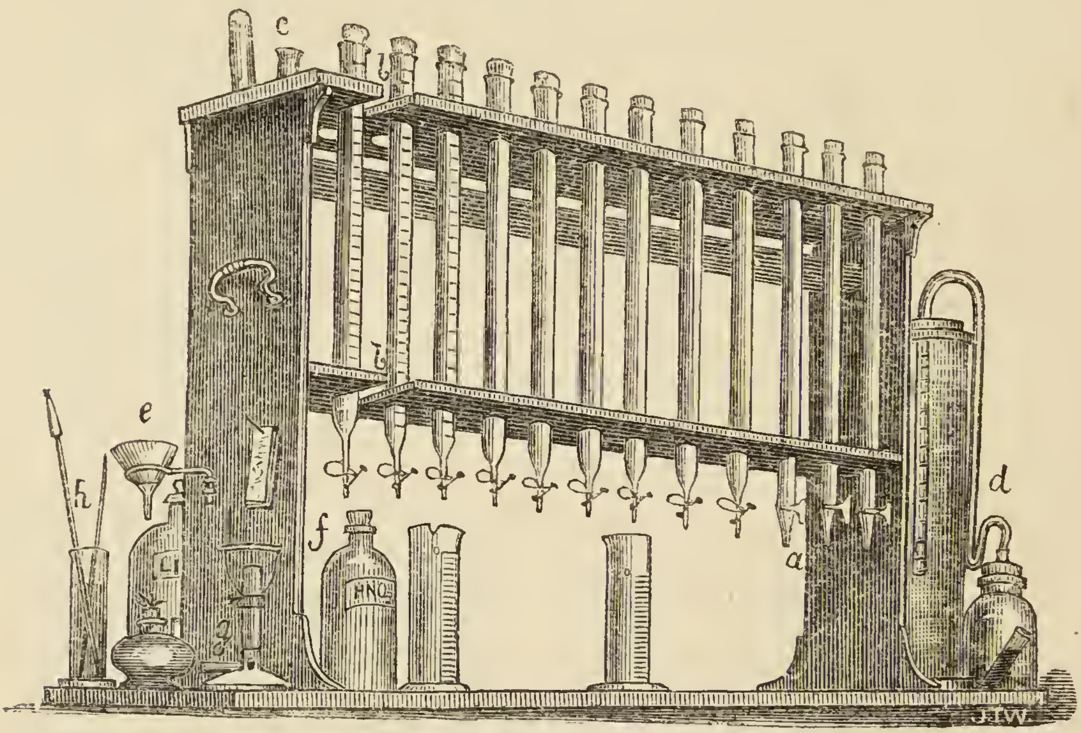


Fig. 4.

The burettes are graduated in cubic centimetres (centilitres) and tenths of centimetres. They are fitted with india-rubber tubes with pinch-cocks and glass nozzles, besides being furnished with caps or corks of india-rubber, which may be removed or loosened at the moment of use.

The burettes are supported by india-rubber

rings to prevent them slipping in the slots cut in the boards, *b*, *b*. Only one of the slots is shown to retain simplicity in the figure. The rings are such as are used on umbrellas. A strip of thin brass may be used to keep the burettes in their places.

Two or three of the burettes required for such caustic reagents as nitric acid, liquor potassæ, liq. sodæ, bromine, are better made with glass stop-cocks.

The top of the frame is utilized as a stand for test-tubes, with pins and holes as seen at "*c*," and by the two test-tubes in position.

Filters can be arranged, as at "*e*," by wire rings, which swing in wire staples.

Other requisites are disposed about the frame—the ureameter; Bunsen burner, fitted with ring for holding porcelain dish; spirit lamp; test papers in box; strips of blotting paper. The pipettes shown at "*h*" should be kept in a urine-glass filled with clean water to prevent fouling. They should be made of $\frac{1}{8}$-in. tubing, drawn to a fine point, and fitted with nightcaps made of a bit of rubber tubing, as shown in the illustration. By pressure and expansion of the nightcap the exact amount of the deposit at the spot wanted can be conveniently managed.

The bottom of the frame can be arranged as

a drawer, in which to keep test papers, urinometer, spare pipettes, filter papers, glass stirring rods, porcelain dishes, sheets of white paper, microscopic slides, covers, mounting apparatus, labels, etc.

The Standard Solutions mostly wanted are :—

1. *Nitric Acid.*—For albumen test.

2. *Methylated Spirit of Wine.*—For albumen when known to be in small quantities.

3. *Liquor Potassæ.*—For sugar test (Moore's).

4. *Copper Sulphate.*—For estimation of sugar (Fehling).

5. A. *Nitrate of Mercury.*—Solution for estimation of urea (Liebig).

6. B. *Nitrate of Mercury.*—Solution for estimation of chlorides.

7. *Solution of Baryta.*—For precipitation of phosphates preliminary to test for urea and chlorides.

8. *Nitrate of Silver.*—Solution for estimation of chlorides.

9. *Acetate of Uranium.*—For estimation of phosphates.

10. *Acetate of Sodium.*—Solution for assisting 9.

11. A. *Caustic Soda.*—For ureameter.

12. B. *Caustic Soda.*—For indication of acidity.

13. *Bromine.*—Must be kept in a small burette graduated in minims.

Acetic acid, liquor ammonia, sulphate of magnesia in solution may be kept in bottles.

One or two of the burettes should be kept for measuring and dilution of urines.

In testing for urea, chlorides, phosphoric acid, the calculations *per diem* will be simplified by using precipitating glasses graduated in ounces, and operating upon a fixed quantity, say 1 ounce. When this quantity has been determined it will be easy to multiply the result by the number of ounces voided during the day.

Preparation of Standard Solutions.

(3.) *Liquor Potassæ.*—Four ounces of the carbonate of potash dissolved in 6 ounces of water, and solution filtered. Sp. gr. 1·12.

(4.) *Solution of Copper Sulphate.*—Sulphate of copper, 44·88 grammes (= 692·67 grains = 11 drams, 32·67 grains). Tartrate of potash (neutral), 194·37 grammes (= 2298·9 grains = 38 drams, 18·9 grains). Solution of caustic potash of sp. gr. 1·12, 850 to 900 c.c. Water, to 1 litre. 10 c.c. of this solution indicate 1 grain of grape sugar.

(5. A.) *Solution of Nitrate of Mercury.*—71·48 grammes (=1103·93 grains) of pure mercury are dissolved in pure nitric acid upon a sand bath. When nitrous fumes cease to be given off, and a drop of the solution gives no precipitate with chloride of sodium, the solution may be evaporated on a water bath to the consistency of a syrup. It is then to be diluted to make up a volume of 1000 c.c. or 1 litre. If at any time the solution becomes turbid, it may be cleared by the addition of a few drops of nitric acid.

If commercial quicksilver be used an excess must be weighed out, and the process of solution in the nitric acid stopped before the mercury is completely dissolved. The solution is set aside to cool for crystals of protonitrate of mercury to form. The crystals are washed on a filter with a little nitric acid, then boiled with nitric acid till vapours of nitrous acid cease to be given off, and the solution gives no precipitate with chloride of sodium. Evaporate to the consistency of a syrup and dilute as before. The proportion of mercury may be estimated by sulphuretted hydrogen or potash.

10 c.c. of this solution indicate 1·54 grains of urea. For greater convenience in calculations for *per diem*, the solution may be arranged thus—

10 c.c. indicate 1·54 grains of urea, ∴ 1 grain of urea will be indicated by 6·5 c.c.

c.c. c.c.
6·45 : 10 :: 1000 : 1538·46 and 1 c.c. = 153·846 c.c. of dilution; instead, therefore, of diluting to 1000 c.c. dilute to 153·846 c.c., then every c.c. will indicate 1 grain of urea.

(6. B.) *Solution of Nitrate of Mercury*, for estimating the chlorides, consists of 17·06 grammes (263·47 grains) of pure mercury dissolved in cold nitric acid; the protonitrate thus formed dissolved and diluted as before to 1000 c.c. Then 1 c.c. indicates ·154 grain of chloride of sodium, or, diluted to 153·846 c.c., 1 c.c. indicates 10 grains of the chloride.

(7.) *Solution of Baryta.*—One volume of a cold saturated solution of nitrate of baryta ($Ba\,O$, N_2O_5) and two volumes of saturated baryta water ($Ba\,O$, $H_2\,O$) are mixed together.

The barium nitrate is obtained in transparent colourless octahedrons, which are anhydrous. The baryta water is prepared from caustic baryta or barium hydrate.

This solution is used to remove the phosphates from urine previous to testing for urea or chlorides.

(8.) *Solution of Nitrate of Silver.*—For estimating the chlorides.

By the formula $Ag\,NO_3 + Na\,Cl = Ag\,Cl + Na\,NO_3$.

$Ag = 108$	$108 = Ag$
$N = 14$	$35{\cdot}5 = Cl$
$3O = 48$	$23 = Na$
$Na = 23$	$14 = N$
$Cl = 35{\cdot}5$	$48 = 3O$

170 grains of silver nitrate indicate 58·5 grains of sodium chloride, and 2·906 of silver indicate 1 grain of chloride. Then if every c.c. of the standard solution contains 29·06 grains of silver, 10 grains of the chloride will be precipitated by every c.c.

(9.) *Solution of Acetate of Uranium.*—A quantity of uranium oxide, or of the yellow urano-sodic carbonate is dissolved in acetic acid, and the solution diluted so that 1 c.c. precipitates 5 milligrammes (·0077 grain) of phosphoric acid, or 50 c.c. of a sodium phosphate solution are precipitated by 20 c.c. of the uranium solution, and there is yet a slight excess of uranium solution in the fluid to give the test with ferro-cyanide of potassium. The strength of the solution is ascertained by means of a standard solution of phosphate of soda, of which 1 litre contains 10·085 grammes (= 155·65 grains), 50 c.c. contain ·1 gramme (15·432 grains) of phosphoric acid, P_2O_5. To do

this 50 c.c. of the phosphate solution are mixed with 5 c.c. of the sodium acetate solution and heated to near boiling. The uranium solution, of unknown strength, is added slowly, until a few drops filtered through paper produce a distinct reddish-brown reaction with ferro-cyanide of potassium in a watch glass set on white paper. The solution is still further diluted till the reaction with ferro-cyanide begins to disappear. The standard solution of uranium should contain 22·2 grammes of the acetate (= 342·63 grains), equal to 20·3 grammes (= 313·3 grains) of the oxide (Ur_2O_3) in each litre. Every c.c. of uranium used indicates ·5 milligramme (= ·00771 grains) of phosphoric acid.

(10.) *Acetate of Soda.*—Solution to assist the acetate of uranium in separating the phosphoric acid from combination with its salts in urine.

100 grammes (= 1543·4 grains) of acetate of sodium and 50 c.c. of dilute acetic acid are dissolved in water and diluted to make up 1 litre.

(11. A.) *Caustic Soda.*—Solution for liberation of nitrogen in ureameter.

100 grammes dissolved in 250 c.c. of water.

(12. B.) *Caustic Soda.*—Standard solution for determining amount of acidity.

Dissolve 1 gramme (15·434 grains) of dry oxalic acid in as much water as bulks to 100 c.c.

10 c.c. are now measured off into a urine glass and coloured red with tincture of litmus. A dilute solution of caustic soda is cautiously added until the red colour is turned to the original blue. If 6 c.c. of the soda solution have been used in effecting this, they would correspond to 1 decigramme ($\frac{1}{10}$ gramme = 1·54 grains) of oxalic acid. 600 c.c. of the soda solution are now diluted up to 1000 c.c. (1 litre). 1 c.c. of this standard solution neutralizes 10 milligrammes (·0154 grain) of oxalic acid.

Table of the Standard Solutions, with their Urinary Products.

(4.) Copper sulphate, 1 c.c. indicates $\frac{1}{10}$ grain of sugar.

(5. a.) Nitrate of mercury, 1 c.c. indicates 1 grain of urea.

(6. b.) Nitrate of mercury, 1 c.c. indicates 10 grains of chlorides.

(8.) Nitrate of silver, 1 c.c. indicates 10 grains of chlorides.

(9.) Acetate of uranium, 1 c.c. indicates ·0071 grain of phosphoric acid.

(12. b.) Caustic soda, 1 c.c. indicates ·0154 grain of oxalic acid.

UREAMETER.

The markings on the burette are calculated as follows:—By the formula COH_4N_2 $(12+16+4+(14\times 2)=28$ parts of nitrogen are indicated by 60 parts of urea. As 1 litre of hydrogen weighs ·0896 gramme, 1 litre of nitrogen will weigh $\cdot 0896\times 14$ grammes; but, as 1 litre is equal to 61·028 cubic inches, and 1 gramme to 15·434 grains, $\frac{\cdot 0896 \times 14 \times 15\cdot 432}{61\cdot 028}=1$ cubic inch of nitrogen will weigh ·3172 grain. Then, as 28 parts of nitrogen are evolved from 60 parts of urea, 1 cubic inch of nitrogen will be evolved from $\frac{\cdot 3172 \times 60}{28}=\cdot 679$ grain of urea, and conversely 1 grain of urea will evolve 1·472 cubic inches of nitrogen. Obtain sectional area of burette by squaring its internal diameter, and multiplying by the ratio ·7854, the result, divided into 1·472 cubic inches, will give the length of a marking indicating 1 grain of urea; or successive bulks of water equal to this capacity filled into the tube will give the markings. If grains of urea per ounce of urine are required, we find that the quantity of urine used, 65 ♏, is to 1 oz.

(480 ♏) as 1 is to the factor 7·385, so that length of marking obtained as above, divided by this factor, will measure off lengths indicating grains of urea per ounce of urine tested.

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Uric acid	1·00
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